OAT DISEASES
And Their Control

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Contents

	Page
Fungus diseases	1
Crown rust	1
Stem rust	4
Smuts	4
Septoria blight	5
Helminthosporium diseases	5
Helminthosporium leaf blotch	5
Helminthosporium culm rot	6
Victoria blight	6
Fusarium blight	6
Root rot	6
Minor fungus diseases	7
Downy mildew	7
Powdery mildew	7
Ergot	7
Anthracnose	7
Snow mold	7
Bacterial diseases	8
Halo blight	8
Bacterial stripe blight	8
Virus diseases	8
Soilborne oat mosaic	8
Barley yellow dwarf	9
Blue dwarf	9
Nonparasitic diseases	9
Blast	9
Nonparasitic leaf spot	10
Gray speck	10
Minor nonparasitic diseases	10
Nutritional diseases	10
Miscellaneous causes of damage	10

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OAT DISEASES AND THEIR CONTROL

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Oats rank as one of the major crops grown in the United States. Among the cereal crops, they rank next to corn and wheat in importance.

Oats are subject to a very large number of diseases, a good many of which can cause severe damage. Individual oatfields may be severely damaged or even totally destroyed. Diseases are a major limiting factor in oat production. Averaged over a period of years, oat diseases annually account for millions of dollars worth of damage through their effect on yield and quality of grain. They also play a similar, if not more significant, role in the production of oat forage.

The average annual percentage loss from each of the major oat diseases from 1951 through 1960 are shown in table 1. Data were obtained from 23 oat-producing States. The percentage was based on estimates of the potential total oat production for the United States if diseases had been absent. The causal organisms or other agents and the principal control measures for each disease are also shown in table 1.

FUNGUS DISEASES

Crown Rust

Year in and year out, in the principal oat-growing regions of the world, crown rust is one of the most destructive of all oat diseases. Crown rust occurs almost everywhere that oats are grown but is most serious in humid areas. Crown rust infection results in reduced yields, lower test weight, and increased lodging. The severity of this disease varies greatly from year to year, ranging from negligible to total destruction of certain fields. In years when crown rust is severe, losses over large areas have amounted to 30 percent or more of the potential crop.

In the major oat-growing regions of the United States, the fungus causing crown rust may follow either of two distinct life cycles. In either case the uredial or repeating stage ordinarily first appears on oats at least several weeks before ripening. The uredia appear as bright, orange-yellow, round to oblong pustules (pl. 1, *A*). The bright color and the absence of bits of loose epidermis around the pustules distinguish crown rust from stem rust of oats. The urediospores produced in the uredia are adapted to dissemination by the wind and are blown from infected to healthy plants, producing a new uredial generation every 8 to 10 days, depending on the weather. This cycle can be maintained indefinitely as long as growing oat plants are available. In the Deep South the disease is maintained throughout the winter in this manner on winter-grown oats. The rust then moves north as the oats begin to grow there in the spring.

An alternative life cycle, which is the "complete" life cycle, occurs only in climates having cold winters and where the alternate host buckthorn (*Rhamnus*) is present (fig. 1). As the oat plants begin to ripen, telia appear on them. The telia are black or dark brown and sometimes form in rings around the uredia (pl. 1, *A*). The telia remain covered indefinitely by the epidermis or skin of the plant. The teliospores are adapted to surviving through the cold, northern winters, and in the spring they germinate and form small spores. These small spores cannot infect oats, but are carried by the wind to the young leaves of buckthorn plants, which they do infect. The fungus infection on the buckthorn gives rise to aecia, usually on the undersides of the leaves. The aecia, often descriptively called cluster cups, are orange-yellow, usually round or somewhat irregular, slightly raised structures that are composed of small individual aecial cups (pl. 1, *B*). As the aeciospores mature, they are blown to oat plants where they cause infection that gives rise to uredia. This completes the cycle.

The crown rust fungus is composed of pathogenic strains or races, all of which look alike even under the microscope, and are distin-

TABLE 1.—*Common diseases of oats, the organisms or other agents causing them, principal control measures, and estimated average annual loss to the United States oat crop*

Disease	Causal organisms or other agents	Principal control measures	Loss [1]
			Percent
Crown rust	*Puccinia coronata*	Resistant varieties, buckthorn eradication, early planting.	3.7
Stem rust	*Puccinia graminis*	Resistant varieties, barberry eradication, early planting.	2.3
Smuts	*Ustilago avenae* and *Ustilago kolleri.*	Resistant varieties, seed treatment	.6
Septoria blight	*Septoria avenae*	Good cultural practices, moderately resistant varieties.	1.8
Helminthosporium leaf blotch.	*Helminthosporium avenae*	Good cultural practices, seed treatment, moderately resistant varieties.	.7
Helminthosporium culm rot.	*Helminthosporium sativum*	Avoid susceptible varieties	.2
Victoria blight	*Helminthosporium victoriae*	Resistant varieties	.4
Fusarium blight	Various species of *Fusarium*	Good cultural practices, seed treatment, resistant varieties.	.9
Root rot	Various species of *Pythium, Fusarium, Helminthosporium,* and other fungi.	Good cultural practices, seed treatment	2.4
Downy mildew	*Sclerospora macrospora*	None ordinarily needed	T—
Powdery mildew	*Erysiphe graminis*	do	T+
Ergot	*Claviceps purpurea*	do	T—
Anthracnose	*Colletotrichum graminicola*	do	T
Snow mold	*Fusarium nivale* and *Typhula iotana.*	do	T—
Halo blight	*Pseudomonas coronafaciens*	do	.3
Bacterial stripe blight	*Pseudomonas striafaciens*	do	.4
Soilborne oat mosaic	Soilborne virus	Resistant varieties	.5
Barley yellow dwarf	Aphid-transmitted virus	Resistant varieties, aphid control	3.8
Blue dwarf	Leafhopper-transmitted virus	None ordinarily needed	.3
Blast	Various unfavorable growing conditions.	Resistant varieties	2.5
Nonparasitic leaf spot	Unfavorable weather conditions	do	.1
Gray speck	Soil deficient in available manganese.	Application of manganese salts to soil or plants, tolerant varieties.	T+

[1] T = trace.

guished by their ability or inability to attack certain varieties of oats. Since about 1930, oat pathologists and breeders have concentrated on breeding for resistance to specified races. During the 1930's races 1 and 6 were the most common, and the varieties Bond and Victoria, both of which were highly resistant to these races, were used to develop the many resistant varieties released during the 1940's.

Victoria-derived varieties were well protected from crown rust but were eliminated from the principal oat-growing States by another disease, Victoria blight. Bond-derived varieties, such as Clinton, then took over and

performed very well until newer and previously rare races of crown rust, principally race 45, built up to a point where the resistance of the Bond varieties was virtually useless. Efforts were then directed towards producing new resistant varieties using Landhafer and Santa Fe, which were resistant to race 45 as well as to the older races.

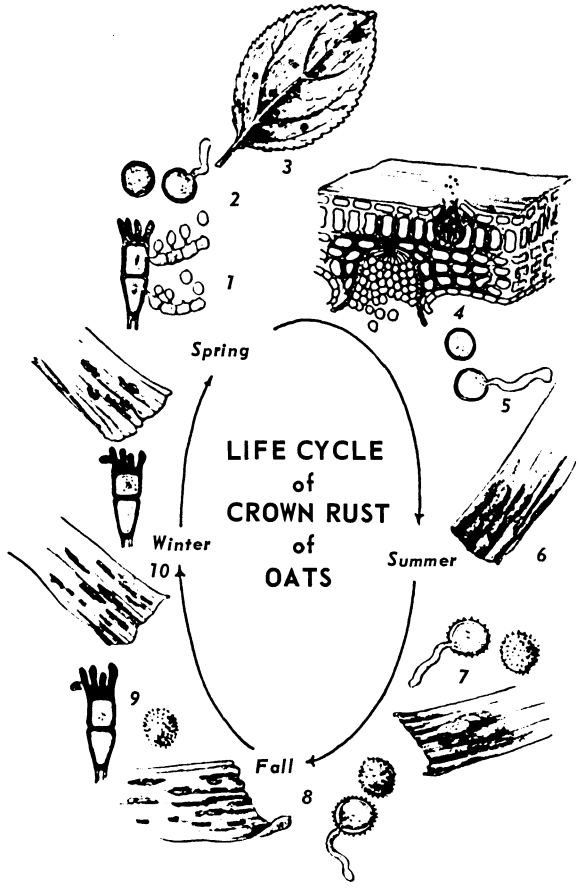


FIGURE 1.—Life cycle of crown rust of oats. Overwintering black spores (teliospores) (1) germinate in the spring and produce several very small spores (basidiospores) (2). If these spores lodge on the leaves of the buckthorn, they will germinate there. The resulting infection of the buckthorn (3) produces spermagonia and cluster cups (aecia) (4). Cluster-cup spores (aeciospores) are blown to nearby oatfields, where they germinate (5) and infect the oats, causing summer-spore pustules (uredia) (6) to develop on the leaves and leaf sheaths. These pustules bear the summer spores (7), which reinfect the crop, producing more of their kind (8) until the infected plants begin to ripen, when the black spores (teliospores) (9) (10) appear, mature, and spend the winter on residue of infected plants, where they germinate the following spring. In the winter-oat States summer spores may infect the fall-sown oat crop, and the rust may overwinter there and continue its existence without the intervention of the cluster-cup stage.

Bond-derived varieties had scarcely been perfected when new races of crown rust, such as 264 and 290, which could attack them, were discovered in North America. These races are widely distributed and now represent a major threat to currently grown oat varieties. Newer varieties utilizing the resistance of Trispernia, Florad, Florida 500, P.I. 174545, and other cultivated varieties are now being produced. Already, rare races are known that parasitize some of these, and on the basis of past experience, it seems likely that all will eventually become susceptible. Thus, we can see that developing crown rust-resistant varieties is a never-ending battle involving the plant breeder's ability to develop new resistant varieties, and the crown rust organism's ability to produce new races that can attack them.

Research is now underway to study the utilization of the many types of very high resistance known to occur in wild oat species from the Mediterranean region. Cultivated varieties with such types of resistance may have a longer useful life than resistant varieties of the past. Another approach involves the production of varieties that are uniform in appearance but are a mixture of similar lines that differ only in the type of crown rust resistance they carry. Attention is also being given to "tolerance," which is the ability of certain susceptible varieties to tolerate rust infection with relatively little effect on yield or grain quality.

The three principal control measures for crown rust are the use of resistant varieties, eradication of the alternate host, and early planting. Varietal resistance, an excellent control when available, has been discussed above. In the colder sections of the country, destruction of buckthorn bushes eliminates an important source of early-season infection in oatfields. The buckthorn also serves as an efficient breeding ground for new races of the fungus, and eradication of buckthorn will increase the effectiveness of resistant varieties by slowing down the appearance and spread of new, virulent races. In the spring oat areas, early planting is advisable since it enables the oat crop to mature before the crown rust fungus has had time to build up to damaging proportions. For the same reason, early maturing oat varieties generally suffer less rust damage than later maturing varieties.

Experimental work has shown that fungicides control crown rust, but the cost is ordinarily prohibitive.

Stem Rust

Stem rust is of major importance on oats and occurs almost everywhere that oats are grown. Like crown rust, it is more serious in humid areas and can cause severe damage when conditions are favorable. It is in fact quite capable of causing damage of the same magnitude as that caused by crown rust. Widespread losses due to stem rust, however, have occurred less frequently over the years. Damage is expressed primarily in terms of reduced yields and lower bushel weight, accompanied by lodging.

The life cycle and spore stages of the stem rust fungus are very similar to those of crown rust, except that the common barberry (*Berberis*) is the alternate host. The uredia and telia occur on the stems, leaf sheaths and blades, and panicles of the oat plant. The pustules of the uredial stage are large, usually oblong, and dark, reddish brown (pl. 1, *C*). The epidermis of the host is ruptured and often pushed up around the edges and through the center of the pustules so that it is easily visible. The dark, characteristic color of the pustules distinguishes stem rust readily from the light, orange-yellow crown rust. As the host plant approaches maturity, telia begin to form in and around the uredia, particularly on the stems and sheaths (pl. 1, *C*). The telia are black, usually oblong, and exposed by rupture of the epidermis. The general appearance of the aecia of the stem rust fungus on barberry is similar to that of the aecia of the crown rust fungus on buckthorn. Stem rust, too, can overwinter in the Deep South on winter-grown oats.

The stem rust fungus is composed of pathogenic strains or races, but these have not been nearly as numerous as those of the crown rust fungus. They are, nevertheless, very important and must be taken into account when any phase of resistance is considered. New and more virulent races of stem rust have recently appeared in the United States, accompanied by some striking changes in race prevalence and distribution.

Control measures recommended for stem rust parallel those for crown rust. The most important single control measure is to plant adapted resistant varieties. Early planting also results in less damage from stem rust and is, of course, beneficial from the standpoint of general growth of the crop. An intensive campaign of barberry eradication has been carried out for quite a number of years, and few barberries are left in the major oat-producing regions of the United States. Wherever they remain, they should be destroyed. Fungicides will control stem rust, but as with crown rust, the cost is ordinarily prohibitive.

Smuts

Loose smut and covered smut are two of the most common and widespread diseases of oats. Before the development of resistant varieties, smuts ranked next to the rusts in importance. Unlike the rusts, they can cause serious losses in the drier areas of the country. In years when smut has been severe, over one-half of the panicles of oats in individual fields have been smutted, and losses over larger areas have averaged as much as 20 percent.

The two smut diseases have similar life histories, are controlled by similar methods, and are difficult to distinguish under some conditions (pl. 1, *D*). For these reasons, they will be considered together.

The sori, or spore balls, of the loose smut fungus form in the oat panicle, usually destroying most or all of the seed and hulls. The sori appear as dark-brown to black, loose, powdery spore masses. Wind and rain usually dislodge most of the spores soon after they appear, and infected panicles are often inconspicuous in the field.

The sori of the covered smut fungus do not ordinarily destroy the outer hulls, and the spore masses remain more or less intact inside the hulls until threshing time. Types of sori appearing to be intermediate between loose and covered smut are not uncommon.

The disease cycle of loose smut begins when the spores are blown from infected panicles to the developing grain on other plants. This may be any time between the time the healthy panicles are flowering until the time the grain is ready for harvest. The spores of the covered smut fungus, and probably those of the loose smut fungus also, are transferred from infected panicles to noninfested seed when the spore balls are broken and scattered during threshing. The spores remain dormant on the seed, either outside or inside the hulls, until the seed is planted. The spores germinate as the seed germinates, and the very young seedling is infected as it emerges from the seed. The fungus grows within the plant and keeps pace with the growing plant, but it causes little or no visible stunting or other symptoms until the plant heads. The spore masses are produced in the young panicle before heading, and the cycle is completed as the smutted panicle emerges from the boot.

The smut fungi, like the rust fungi, are

composed of pathogenic strains or races. However, plant pathologists and breeders have been relatively successful in developing oat varieties resistant to all common races of both smuts. Control by the use of resistant varieties is generally regarded as quite satisfactory. In addition to the use of resistant varieties, both smuts can be controlled by seed treatment. Several new systemic fungicides in preliminary investigations have controlled loose and covered smuts. However, these fungicides are not registered and cannot be recommended before registration. Most of the organic-mercury seed-treatment materials, which are available on the market under numerous trade names, usually control smut if applied strictly according to the manufacturers' directions.

CAUTION: Grain treated with organic-mercury materials is extremely hazardous to humans and livestock, and safety precautions recommended by the manufacturer should be followed carefully. Seed treatments may prevent the appearance and buildup of new smut races capable of attacking resistant varieties and also control certain other diseases.

Septoria Blight

Certain species of the *Septoria* fungus have long been known to parasitize oats, but it was not until the late 1940's that one of these was recognized as the cause of a major oat disease. In some years, the disease has caused appreciable losses in the North Central States.

Any of the aerial parts of the oat plant may be infected. On the leaves, lesions are circular to elongate, light yellow to dirty white in the center, surrounded by a band of dull brown, which is in turn surrounded by yellowish tissue blending into green (pl. 2, *A*). The center of the lesion may be dotted with scattered small, dark, spore-producing bodies called pycnidia. Infection of the culms sometimes causes severe lodging. Lesions are greyish brown to shiny black, generally beneath the leaf sheath. The hulls of the grain and sometimes even the groats may become infected and turn black.

The fungus overwinters on stubble and oat straw left in the field. In the spring spores are produced on this material and are blown by the wind to the green grain. The initial infections (micropycnidia) are mainly on the leaves. When these infections or micropycnidia produce spores, they are washed by the rain or dew down the leaf blade to the sheath, giving rise to sheath and stem infection. Damage may be severe if this occurs while the stem is still soft and green. Damage is slight if infection occurs at later stages of development. The spores may also reach the panicle by splashing rain or by the wind rubbing plants together. The disease does not appear to be ordinarily transmitted by the seed.

Various varieties of oats show different reactions and different amounts of infection by septoria blight. Developing highly resistant varieties has proved to be difficult. Some varieties, however, are decidedly less susceptible than others, and the choice of such moderately resistant varieties is recommended as a control measure. Crop rotation should also help to prevent the disease from building up to serious proportions. Seed treatment will probably have little effect. Fungicides applied as a foliar spray will control the disease, but the cost is ordinarily prohibitive.

Helminthosporium Diseases

Three species of the *Helminthosporium* fungus cause economically significant diseases of oats in the United States. These diseases in certain years have been very important and have caused widespread damage.

Helminthosporium Leaf Blotch

Helminthosporium leaf blotch is one of the most serious oat diseases in Southern United States. In the North Central States it is common but not usually serious. In the seedborne phase of the disease, the seedlings emerge with a twisted or contorted appearance, and narrow brown stripes occur on the first, second, and third leaves. The fungus may also overwinter on crop residues of the previous year. Secondary infection of older leaves is initiated by windborne spores produced on diseased seedlings or from spores produced on crop residues of the previous year. On the older leaves the lesions start as small, brown flecks, which develop into more or less well-defined longitudinal strips of dead tissue (pl. 2, *B*). In severe attacks a high percentage of the leaf is destroyed.

Oats resistant to helminthosporium leaf blotch are rare, but some varieties are less susceptible than others; and selection of these moderately resistant varieties, when available, is suggested as a control measure. Because the disease is carried over the winter on the seed and on oat stubble and straw left in the field, seed treatment can be expected to help but will not give complete control. Crop rotation should be beneficial in reducing the amount of inoculum present to start the disease in the spring.

Helminthosporium Culm Rot

Helminthosporium culm (stem) rot of oats is apparently most serious in the Southeastern States. Roots and crowns of infected plants are also rotted (pl. 2, *C*). This disease is not perfectly understood, but certain varieties are obviously more susceptible than others. Avoiding these varieties is suggested as a control measure.

Victoria Blight

In 1945, a new and devastating helminthosporium disease appeared on varieties of oats that possessed the Victoria type of crown rust resistance. This soon proved to be one of the most destructive plant diseases ever known, reducing yields of susceptible varieties in the North Central States by as much as 50 percent. It is apparently much less severe in the Southern and Western States.

Infected plants show longitudinal bronze or lead-colored striping of the leaf blades and sheaths, a basal stem and root rot, and an abundant, black sporulation of the fungus on the nodes of mature plants (pl. 2, *D*). Infected stems often break over near the ground line. The disease is caused by a fungus that produces a toxin or poison that spreads throughout the plant.

All varieties of oats having the Victoria type of crown rust resistance are susceptible to Victoria blight; whereas all other varieties are immune or highly resistant. Consequently, the use of resistant varieties is a practical, effective control measure. The fungus is seedborne and also lives over winter on crop residue and in the soil. Consequently, crop rotation and seed treatment can be expected to help but will not give complete control.

Fusarium Blight

Many species of the *Fusarium* fungus attack oats in the United States. The damage caused by these fungi is more severe in the North Central States and other northern areas than in the South. Reasonably accurate estimates of actual amounts of damage are difficult to make, but fusarium blight very likely reduces yields appreciably; and isolated instances of severe damage have been reported.

Affected plants occur singly or in patches of variable size. The development of this disease may involve invasion and killing of the young plants either before or after emergence. If the young plants are not killed outright, infection may later reach the crown, resulting in small plants with few tillers. Head blight is not as common on oats as on other small grains; however, diseased kernels occasionally become sufficiently concentrated to be a menance to livestock, as is scabby barley. Infected oat spikelets are light and chaffy and either light pink or buff.

Oat varieties differ in reaction to the *Fusarium* fungi, and the use of the more resistant varieties is suggested as a control measure. The fungi can overwinter on the seed, crop residue, or organic matter in the soil. Consequently, seed treatment and crop rotation can be expected to help but will not give complete control. Early planting, which allows the plants to develop at temperatures too low for the best growth of these fungi, is probably beneficial.

Root Rot

Several of the fungi already discussed, such as species of *Helminthosporium* and *Fusarium*, attack the roots of oats as well as other parts of the plant. Other fungi, the most important of which are probably species of *Pythium*, attack mainly the roots and newly germinated seedling plants (pl. 3, *C*). Because of the nature of these diseases, an accurate estimate of damage is difficult to make. However, the root disease complex is one of the more important diseases of oats in the humid areas.

Pythium fungi may attack the seed so rapidly that the embryo is killed before germination, or the young seedling may be killed before emergence. Plants attacked, but not killed, are yellow and stunted. As the season advances, they gradually turn green but never fully recover. On the roots, water-soaked translucent areas, which later turn reddish brown, are evident.

In general, any factor retarding the growth of the plant and directly affecting the fungus makes injury more pronounced. Conversely, plants grown under optimum conditions of temperature, water supply, and fertility are not apt to be seriously affected by root-rotting fungi. Consequently, the most important control measure is the application of good cultural practices. Although these fungi usually live in the soil, seed treatment with volatile organic fungicides can be expected to help but will not give complete control. Damage has been shown to be greater to plants grown from seed stored for several years than to plants grown from newer seed. Plants grown from small seeds are also attacked more severely than plants grown from large seeds. No highly resistant oat varieties are known, but some are more resistant than others.

Minor Fungus Diseases

A very large number of additional fungi are known to parasitize oats. The majority of these ordinarily cause little or no actual loss in yield or quality of grain. Nevertheless, some are occasionally important in restricted areas of the United States or in other countries. For these reasons a few of the potentially more important diseases caused by these fungi will be discussed briefly.

Downy Mildew

In the South downy mildew has been known to cause severe damage in individual flooded fields. Infected plants tend to be stiff and upright. The upper leaves may be curled about the panicles, and the panicles are often curled and twisted, sometimes so severely that the panicle is reduced to a cluster of frayed and tangled spikelets (fig. 2). Curved, elongate structures also occur in the panicle. The thick-walled spores of the fungus are well adapted to persisting in the soil, and the disease is carried from one locality to another in spore-bearing plant residue, in seed grain, and by wind and water. Control measures are not ordinarily needed. Avoiding areas likely to be flooded is helpful.

Powdery Mildew

Powdery mildew is not uncommon on oats. It has been reported as a serious disease, reducing forage yields of susceptible varieties only in a very few instances in the Southern States. The fungus is an external parasite appearing first as patches of white fluffy growth on the lower leaves and leaf sheaths (pl. 3, *A*). As the disease progresses, the patches become powdery, turn gray or brown, and may eventually cover extended areas of oat tissue. If control measures ever become necessary, resistant varieties probably could be found and used.

FIGURE 2.—Downy mildew on oat panicles. Panicle on extreme right is healthy. (Photograph courtesy of Iowa State University of Science and Technology, Department of Botany and Plant Pathology.)

Ergot

Ergot has never been regarded as a serious disease of oats in the United States, but individual panicles showing infection are not rare. The disease is readily identified by the large, purple-black, horn-shaped fungal bodies called sclerotia, which appear in place of the seed (fig. 3). These sclerotia, like ergot sclerotia of other cereals and grasses, must be regarded as poisonous to humans and livestock. Control measures are not ordinarily needed.

Anthracnose

Anthracnose is not ordinarily considered a serious disease of oats but is widespread, particularly in the Southern States where it is occasionally responsible for isolated instances of appreciable damage. The disease appears as brown, oval to elongate lesions, dotted with the dark-brown sporulating bodies of the fungus on the leaves and sheaths. Infection may occur in the stem and roots, and infection of the panicles results in light-weight and shriveled grain. Late in the season severely infected plants are characterized by their small size and paucity of tillers. Should control measures be warranted, resistant varieties probably could be found and used. The disease does not appear to be seedborne and probably overwinters on the residue of infected plants in the field. Consequently, crop rotation and good cultural practices can be expected to help but will not give complete control.

Snow Mold

Snow mold has been recognized as a disease of potential importance on winter oats, as the crop is moved northward through the development of more winter-hardy varieties. The fungus is conspicuous as white superficial mycelium on the leaf and crown tissues of winter oats as snow melts in the spring. The resulting dead plants are matted tightly to the ground with a whitish-gray, bleached appearance (pl. 3, *B*). The disease usually occurs in local areas, or spots, with healthy plants adjoining. Differ-

FIGURE 3.—Ergot on oats.

ences in varietal reaction to snow mold of oats have been reported. Should control measures be warranted, resistant varieties are available.

BACTERIAL DISEASES

Halo Blight

Halo blight is the most common bacterial disease of oats, occurring to some extent each year in the major oat-growing regions of the country. Although there have been occasional reports of appreciable damage, average losses from this disease are very small.

Halo blight appears in the Northern States early in the season, usually earlier than any of the diseases caused by leaf-spotting fungi. It is evident by lesions mainly on leaves, although they are also found on other parts of the plant. The lesions, first light green and later yellow (pl. 4, *A*), are small oval chlorotic spots surrounded by a halolike border. Severely infected leaves later turn brown and die back from the tip. Where highly susceptible varieties are involved, the dead leaf tips may include several inches of the leaf not occupied by lesions, indicating considerable additional indirect damage. A seed-rotting phase of the disease also occurs.

The bacteria overwinter on the seed and plant residue in the field. Plant residue is the most important source of inoculum in the spring. The disease is favored by cool, wet weather and is checked by warm, dry weather.

Different varieties of oats show differing degrees of resistance, and where control is necessary, the use of resistant varieties and seed treatment is recommended.

Bacterial Stripe Blight

Bacterial stripe blight of oats is widespread over the United States, but is seldom as prevalent or noticeable as halo blight. Lesions on the leaves first appear as sunken, water-soaked dots, which may join to form long, water-soaked stripes or blotches (pl. 4, *B*). These stripes may show narrow, yellowish margins. A bacterial exudate is formed, which dries down to thin, white or colorless scales. The lesions occur mainly on the leaf blade but may occasionally be found on other parts of the plant. Halolike borders do not develop around these lesions. The life cycle of bacterial stripe blight is similar to that of halo blight. Control measures are not ordinarily needed.

VIRUS DISEASES

Several virus diseases of oats are known. At least two, soilborne oat mosaic and barley yellow dwarf, have been known to cause serious losses in the United States and should be ranked as major oat diseases.

Soilborne Oat Mosaic

This severe mosaic disease of oats occurs in the Southeastern States. It is caused by a virus that comprises at least two distinct strains. In years favoring the disease the virus can reduce yield as much as 50 percent in some susceptible varieties.

In its most destructive form, soilborne oat mosaic causes infected plants to grow in small rosettes. Less severe symptoms include light-green to yellow dashes and streaks paralleling the axis of the leaf, and sometimes a necrotic mottling (pl. 5, *D*). Other strains of the virus may induce the appearance of eyespot lesions

that are spindle shaped with light-green to ashen-gray borders and green centers.

The virus is soilborne and overseasons in the soil. Symptom expression is strongly favored by cold temperatures.

Many highly resistant varieties are known, and the use of these varieties will effectively control the disease.

Barley Yellow Dwarf

Barley yellow dwarf virus (BYDV) was first recognized as a serious disease of oats in the late 1940's. Since that time, several outbreaks have resulted in severe losses in yield and quality. BYDV is usually present in at least trace amounts throughout most of the oat-growing regions of the United States and in recent years has been the most important of all oat diseases.

The disease first appears as yellowish-green blotches on the older leaves, principally near the tips. These areas may then take on a reddish cast, which on different varieties and under different conditions, may range from yellow (pl. 5, *A*) through intermediate stages to brilliant scarlet. When compared with normal plants, infected plants are dwarfed, mature early, produce seed low in bushel weight, and have more blast (pl. 5, *B*). (See next column for discussion of blast.)

BYDV is transmitted by a number of species of aphids. Different strains of the virus exist, and certain species of aphids transmit given strains of the virus more readily than others. The complete life cycle of BYDV is not known as this is written (1968), but it is known that many wild grasses susceptible to the virus may play a part in its overwintering.

Oat varieties highly resistant to BYDV are not known, but some are much more resistant than others. Several new resistant varieties are now being developed. Consequently, the use of the most resistant varieties available and the control of the insect vectors are suggested as control measures.

Blue Dwarf

The virus disease of oats called blue dwarf is transmitted by a leafhopper. Individual plants may be severely infected, but ordinarily only a small part of the plants in a field will be damaged. Infected plants are dwarfed, uniformly dark bluish green, and long lived (pl. 5, *C*). The leaves are shortened, upright, and rigid. Control measures do not appear to be necessary.

NONPARASITIC DISEASES

Several nonparasitic diseases of oats are known. The most common are blast, nonparasitic leaf spot, and gray speck caused by a manganese deficiency. A number of other nonparasitic diseases occur less frequently.

Blast

Blast of oats refers to a type of sterility appearing at the time of heading in a form of white, empty hulls, usually near the base of the panicle (fig. 4).

Blast appears to be associated with extremes of such factors as temperature, moisture, light, and nutrition that occur at certain critical periods during development of the plant. The amount of blast is usually greater in late-seeded material than in early-seeded.

As different varieties of oats vary considerably in susceptibility to blast, the use of the

FIGURE 4.—*Left*, Oat panicle affected by blast; *right*, healthy panicle.

more resistant varieties, where available, is indicated as one control measure. In general, the better adapted varieties will tend to be more resistant. Good cultural practices can be expected to help but will not give complete control in reducing damage from blast.

Nonparasitic Leaf Spot

Damage by nonparasitic leaf spot often is very conspicuous on oat leaves. It can reduce yields of susceptible varieties under certain conditions. The injury appears, in some cases at least, to be associated with an inability to recover from water soaking due to high humidity. Rapid drying of the foliage, along with an abrupt change from cool-moist to warm-dry environment, accentuates the expression of symptoms on susceptible varieties.

The symptoms of nonparasitic leaf spot vary on different oat varieties and are influenced by environmental conditions. Typically, symptoms are spots, mainly on the leaves. These spots range from ashy gray to straw-colored brown (pl. 4, *C*) and from irregular to circular and elongate. Distinctly concentric areas of different shades of color may be present.

Most commercially grown oat varieties have good resistance to nonparasitic leaf spot, and avoiding susceptible varieties controls nonparasitic leaf spot satisfactorily.

Gray Speck

The gray speck disease of oats, caused by a deficiency in available manganese in the soil, is not common in the major oat-growing regions in the United States. However, it is a problem in alkaline-organic and other low-manganese soils.

The symptoms of gray speck first appear as light-green to gray-brown spots and streaks, mainly on the leaves (pl. 4, *D*). The plants may be greatly reduced in height and yield, and the entire plant may become yellow where the disease is severe.

Gray speck can be controlled by the application of manganese salts to the soil or by spraying the plants with 1 percent manganese sulfate. Certain varieties of oats are much more tolerant of manganese deficiency than others, and the use of such varieties should, in most cases, control gray speck.

Minor Nonparasitic Diseases

Nutritional Diseases

Deficiencies of various other elements in the soil, including nitrogen, copper, boron, zinc, nickel, calcium, molybdenum, iron, and cobalt, also cause diseases of oats. Ordinarily, such diseases are serious only under special soil conditions. Excessive amounts of these elements also may cause diseases.

Miscellaneous Causes of Damage

Herbicides, such as 2,4-D, and high and low extremes of environmental factors, such as temperature, soil moisture, or ozone, may also result in abnormal plant development. Hail (pl. 3, *D*), solid sheets of ice in fields, lightning, and other unfavorable conditions in the physical environment can damage oats. The symptoms of all these nonparasitic diseases may be sometimes confused with those caused by various pathogens.

A

B

C

D

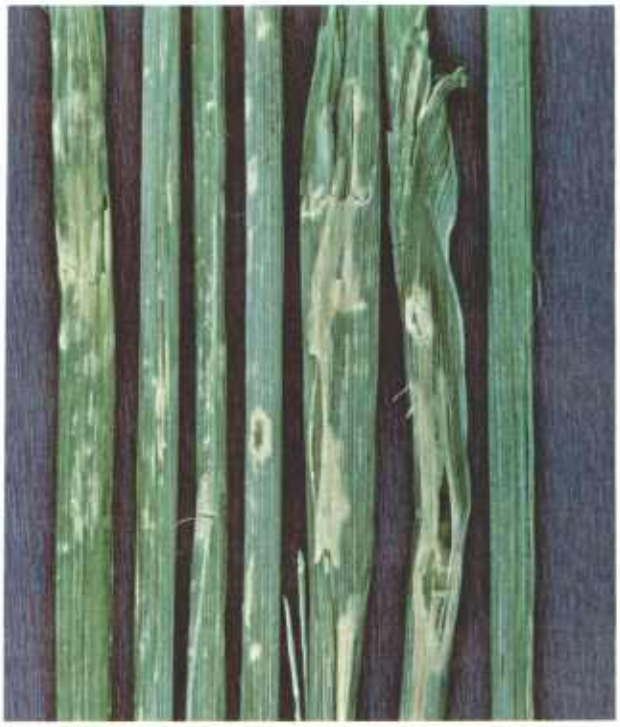
A, *Left* and *center*, telia of crown rust on oat leaves; *right*, uredia. *B*, Aecia of crown rust on buckthorn leaf. *C*, *Left*, telia of stem rust on oat leaves; *right*, uredia. *D*, *Left*, healthy oat panicle; *center*, covered smut on oat panicle; *right*, loose smut.

A, Septoria blight on oat leaves and culms. *B*, Helminthosporium leaf blotch on oat leaves. *C*, *Left*, healthy oat culms; *right*, helminthosporium culm rot on oat culms. *D*, Victoria blight on oat plants.

A

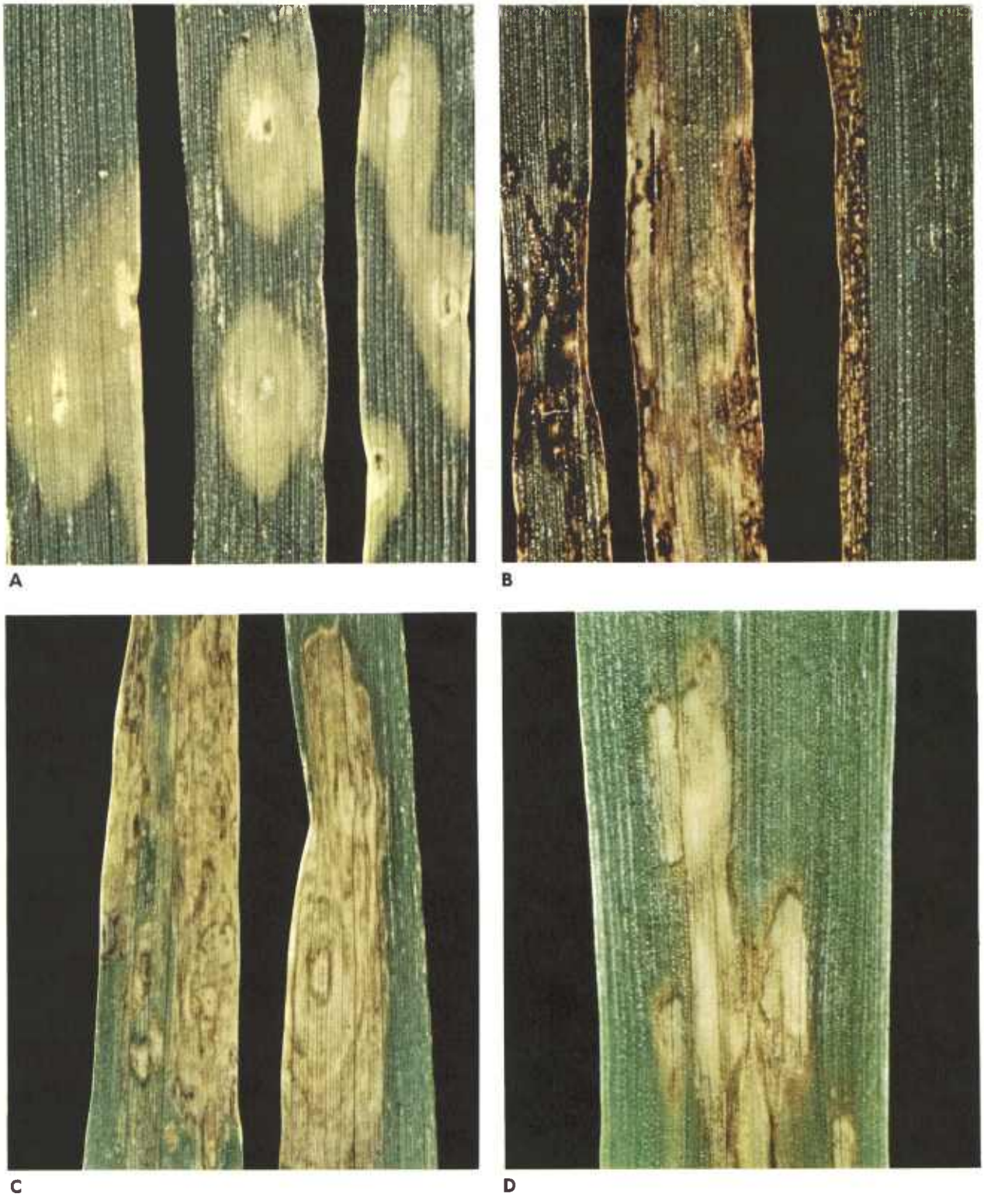
B

C



D

A, Powdery mildew on oat leaf. *B*, *Left*, snow mold on oat plants; *right*, healthy plants. *C*, *Left*, pythium root rot on oat seedlings; *right*, healthy seedling. *D*, Hail damage on oat culms.

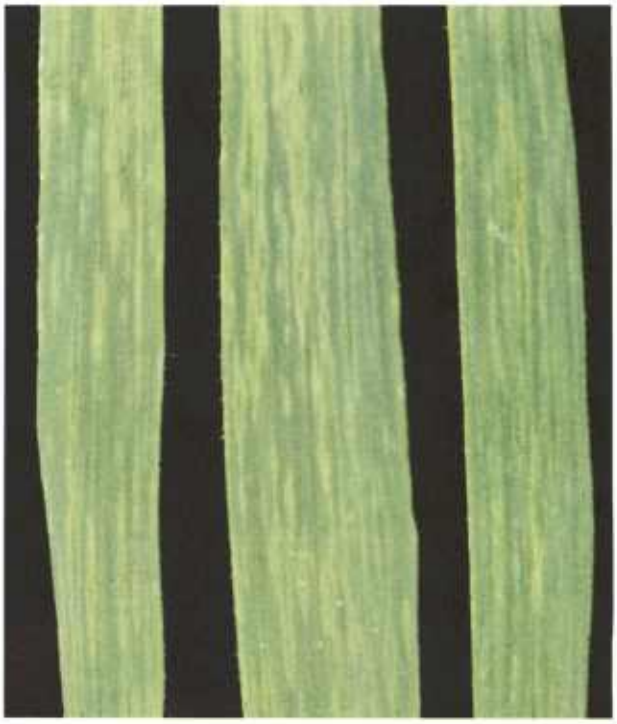


A, Halo blight on oat leaves. *B*, Bacterial stripe blight on oat leaves. *C*, Nonparasitic leaf spot on oat leaves. *D*, Gray speck on oat leaf.

A

B

C



D

A, Barley yellow dwarf on young oat plants. *B*, *Left*, healthy oat plants; *right*, barley yellow dwarf on adult plants. *C*, *Left*, blue dwarf on adult oat plants; *right*, healthy plants. *D*, Soilborne mosaic on oat leaves.

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